LABORATORY STUDIES WITH COMPOUND DRC-1339 ON FERAL PIGEONS

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ABSTRACT: Laboratory studies were conducted to determine an effective DRC-1339 concentration and bait dilution ratio to control pigeons. Treated whole corn baits formulated with Alcolec-s®, corn starch, or corn oil as adhesive agents and 0.25% or 0.37% DRC-1339 diluted 1:5 with untreated corn produced < 10% mortality. DRC-1339 treated whole corn baits (0.25% and 0.37%) diluted 1:0 and formulated with Alcolec-s® produced 20% and 5% mortality, respectively. Whole corn treated with 0.37% DRC-1339, diluted 1:0, and formulated with corn starch produced 68% mortality in laboratory-held pigeons and was selected for further evaluations in field studies to provide efficacy data to the EPA. DRC-1339 residue levels observed in pigeons free-feeding on 0.37% undiluted DRC-1339 treated corn was not detected in breast tissue and only occurred in the gastrointestinal tract of two of five pigeons at 0.06 and 0.19 ppm. DRC-1339 residues observed in pigeons force-fed 21 whole corn kernels treated with 0.37% DRC-1339 (approximately 5 times the LD_{50} dose) were not detectable after 3 h in breast tissue and 24 h in the gastrointestinal tract. DRC-1339 residues in pigeons gavaged with 58 mg DRC-1339 (over 10 times the LD_{50} dose) were detectable in the breast muscle of four of nine pigeons at 0.061 to 0.10 ppm. DRC-1339 residues in the gastrointestinal tract ranged from 0.13 to >17 ppm in eight of nine treated pigeons and was not detectable in the remaining pigeon.

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INTRODUCTION

Feral pigeons or rock doves (*Columba livia*) are considered nuisance birds in many rural and urban areas. They have been implicated in crop depredation, contamination of feed and food products, defacing and accelerating building deterioration, and as a vector for the transmission of a number of diseases to humans and other animals (Scott 1961, Thearle 1968, Kreps 1974, Benenson 1985, Krzysik 1987).

A national survey of the U.S. Department of Agriculture, Animal Damage Control (ADC) state directors conducted in 1987 and 1990 indicated that control methods research for pigeons was a high priority (Fagerstone and Schafer 1988, Packham and Connolly 1992). The Federal registration of one such compound, DRC-1339 (3-chloro-4-methyl benzenamine HCl), for pigeon control was especially important. DRC-1339 was developed and registered as an avicide for starlings because of its selective toxicity to most pest birds and lack of toxicity to most predatory birds and mammals (Schafer 1984).

On July 19, 1990 the Animal and Plant Health Inspection Service (APHIS) submitted an application to the U.S. Environmental Protection Agency (EPA) to obtain a Federal Insecticide, Fungicide and Rodenticide Act (FIFRA) Section 3 registration for DRC-1339 Concentrate-Pigeons to control pigeons in and around structures. On July 16, 1992 EPA granted a conditional registration for DRC-1339 Concentrate-Pigeons (EPA Reg. No. 56228-28) for use at 0.37% on whole kernel corn. As a condition of the registration, APHIS committed to conduct "experimental field trials which compare the performances of 0.25% and 0.37% DRC-1339 whole corn baits in controlling pigeons at the types of sites claimed on this product's label. The trials should include five sites per bait concentration and should report changes in apparent numbers in nearby (but apparently independent) pigeon populations over the periods of time that control efforts were undertaken."

The present study was conducted in preparation for these field trials to determine which concentration(s) of Compound DRC-1339 Concentrate-Pigeons on whole corn (0.25% and 0.37%) and bait dilution ratio(s) (1:0 or 1:5) produced mortality >70% in captive feral pigeons. In addition, the study will determine the magnitude of DRC-1339 residues in captive feral pigeons at uniform time intervals up to and including death following self administered or force-fed quantities of DRC-1339.

METHODS

Two hundred-twenty pigeons of unknown sex were trapped at various locations near Denver, Colorado. After capture, equal numbers of pigeons were housed in each of two outdoor quarantine buildings (2.0 x 3.0 x 4.9 m) with free access to whole corn and water for at least 14 days prior to testing. Following this quarantine period, pigeons were randomly selected, weighed and ranked on the basis of weight. These rankings were used to assign pigeons to test groups (n = 10/group) that were balanced by the pigeons weight (i.e., the heaviest birds were grouped, the next heaviest, and so forth to reduce any bias due to size and food intake). Groups of pigeons were housed in 2 x 2 x 2 m test pens in an indoor aviary. There was an 8 to 14 day acclimation period to allow food (whole corn) consumption to stabilize. Following this period, each group of pigeons were randomly assigned to a treatment (i.e., 0.37% DRC-1339, 1:0, corn oil) which also included control groups in a series of free-feeding experiments to determine an acceptable DRC-1339 concentration and formulation. Experiments follow: 1) 0.25% and 0.37% DRC-1339 treated whole corn diluted at 1:0 and 1:5 formulated with Alcolec-s®; 2) 0.37% DRC-1339 treated whole corn diluted 1:0 formulated with corn oil or corn starch and

water; 3) 0.25% and 0.37% DRC-1339 treated whole corn diluted 1:0 and 1:5 formulated with corn starch and water; and 4) 0.37% DRC-1339 treated whole corn diluted 1:0 formulated with corn starch and water. Pigeons were also randomly assigned to two other experiments; 5) where 10 pigeons were each gavaged with 58 mg DRC-1339; and 6) where 12 individually caged pigeons were force-fed 21 whole corn kernels treated with 0.37% DRC-1339 to determine DRC-1339 residue levels in breast tissue and the gastrointestinal (GI) tract at selected times up to and including death.

Test Chemical and Formulation

The product tested in this study was Compound DRC-1339 Concentrate-Pigeons which contains the active ingredient 3-chloro-4-methyl benzenamine HCl, (Starlicide, CAS #7745-89-3). Purity of the technical material which was obtained from Purina Mills, St. Louis, Missouri was verified. Two formulation procedures were used to treat whole kernel corn with the desired DRC-1339 concentrations. For Experiment 1, the amount of DRC-1339 recommended in label instructions was increased 6% to adjust for chemical loss in mixing. Bait formulation was conducted just prior to testing and consisted of mixing 3500 g of whole corn and 4 ml of Alcolec-s® in a hobart mixer for five minutes. DRC-1339 (9.27 g for 0.25% and 13.72 g for 0.37%) was added to corn and Alcolec-s® mixture and mixed for an additional five minutes. Each batch was bagged, labeled, and stored in the dark. A 100 g sample of each concentration was collected and retained for analyses. For experiments 2, 3, 4, and 6, baits were prepared one day prior to testing according to label directions. Based on a 1000 g batch of whole corn, respectively, amounts of DRC-1339 were formulated with 8.7 g of corn oil or 3.1 g of corn starch as an adhesive and mixed with 80 ml of water. The prepared baits were mixed in 1 to 5 kg quantities in plastic bags, and left open under a hood to air dry overnight. A 100 g sample of each concentration was collected and retained for analysis. For Experiment 5 on the day of treatment, 1 g of DRC-1339 was mixed with 17.8 ml of water in a 50 ml beaker.

DRC-1339 Bioassay

During the acclimation and posttreatment period, each group of pigeons had whole corn (70 g/pigeon) available in a 50 cm diameter, 10 cm deep pan from 0700 to 1600 h each day; water was available *ad libitum*. Daily food consumption was recorded at 1600 h. In addition, the number of whole corn kernels under perches were counted and removed at 0700 and 1600 h each day and used as an index of regurgitation. On treatment day, a pan containing its assigned DRC-1339 whole corn treatment was placed in each cage. Observations were made on each cage at 2 h intervals and the time to render individual pigeons incapacitated (sedentary) and to cause death was recorded. Dead pigeons were removed daily, weighed, sexed, necropsied to verify symptoms of DRC-1339 poisoning and crop contents recorded. The same was done to surviving DRC-1339 pigeons following euthanization. Experiments ran for up to seven days posttreatment.

DRC-1339 Residues

In Experiment 3, pigeons which free-fed on undiluted 0.37% DRC-1339 treated whole corn were analyzed for residues. In Experiment 5, pigeons were gavaged using a syringe with a plastic tube with 1 ml of solution containing 58 mg of DRC-1339. This level was based on the average consumption of wild pigeons collected after feeding on untreated whole corn (Dolbeer et al. 1991). In Experiment 6, pigeons were each force-fed 21 0.37% DRC-1339 treated whole corn kernels. Each bait was pushed into the crop with a rounded glass rod. Regurgitation was monitored every 30 minutes during the first 2 h and at 9 h after treatment. Two pigeons were euthanized at 0, 3, 6, 12, 24 and 48 h after treatment for DRC-1339 residue analysis.

Following treatments in experiments 3, 5, and 6, pigeons were checked daily at about 0700, 0900, 1100, 1300, 1500 h. Dead pigeons were immediately collected, weighed, labeled and the number of hours from treatment to collection was recorded. The breast muscle (50 g) and GI tract (30 g) of dead pigeons were prepared for analysis within 3.5 to 14 h of mortality. Analysis was started within one hour of receipt of the tissue samples. Capillary gas chromatography was used to detect DRC-1339 using a method developed at the Denver Wildlife Research Center.

In Experiment 3, duplicate analyses were performed for each submitted tissue sample (seven ground breast muscle and seven blended GI tract). Experience with the analytical method showed that DRC-1339 recovery and method limit of detection (MLOD) varied greatly between samples representing different birds. In addition, analyte residues were rarely observed. Therefore, duplicate sub-samples were fortified with DRC-1339 immediately prior to analysis for use as quality control (QC) samples. These 3 g GI tract and 4.5 g breast muscle sub-samples were fortified with approximately 0.5 μg and 0.8 μg DRC-1339, respectively. This results in fortified tissues with DRC-1339 concentrations of approximately 0.18 μg/g. The chromatographic responses obtained from these fortified sub-samples were used to calculate the analyte recovery and MLOD.

In Experiment 5, analytical procedures were similar to Experiment 3. The 3 g GI tract and 4.5 g breast muscle sub-samples were fortified with approximately 1.1 μg and 1.6 μg DRC-1339, respectively, which resulted in fortified tissues with DRC-1339 concentrations of approximately 0.36 μg/g. DRC-1339 residue determinations were performed on 9 of 10 pigeon breast muscle and 9 of 10 pigeon GI tract samples. The remaining pigeon survived the treatment. The chromatographic responses obtained from the fortified sub-samples were used to calculate the analyte recovery and MLOD.

In Experiment 6, QC samples were not prepared by fortifying tissue sub-samples from each bird as was done in Experiments 3 and 5, because tissues from Experiment 5 (gavage) indicated that DRC-1339 residues could be present in these samples. Composite GI tract and breast muscle samples were obtained from several birds which were known not to contain DRC-1339. For each set of analyses, two GI tract QC samples (1.5 and 15 μg/g) and

one breast muscle QC sample (0.5 μg/g) were prepared. Unfortified (blank) composite tissue samples of each tissue type were also analyzed. These QC samples were used only to evaluate the methodology and not to evaluate analyte recovery or MLOD for the actual samples.

RESULTS

Test Chemical and Formulation

The purity of the DRC-1339 Concentrate-Pigeons used for these studies was 96.9%. DRC-1339 treated whole corn baits used in Experiment 1 and 3 were prepared at nominal concentrations of 0.25% and 0.37%. The DRC-1339 content of baits from Experiment 1, which were adjusted 6% for chemical loss, were 0.25% and 0.38%, and from Experiment 3, 0.19% and 0.27%, respectively. In Experiment 6, bait prepared with nominal concentration of 0.37% was assayed at 0.26%.

DRC-1339 Bioassay

In Experiment 1, 0.25% and 0.37% DRC-1339 treated corn baits diluted 1:0 and formulated with Alcolec-s® produced 20% and 5% pigeon mortality, respectively (Table 1). No mortality was observed when DRC-1339 treated corn baits at the same concentrations were diluted 1:5 with untreated corn, or in control pigeons. Pigeon consumption of DRC-1339 treated corn baits diluted 1:5 was 25% less than pretreatment consumption levels of 14 to 16 g/bird/day. However, the consumption of 0.25% and 0.37% DRC-1339 treated baits diluted 1:0 was reduced by 88% and 89%, respectively (Table 1). Pigeon regurgitation of corn kernels from undiluted (1:0) treatments was 2 to 2.5 times greater than from diluted (1:5) treatments (Table 1).

In Experiment 2, 0.37% DRC-1339 treated corn baits diluted 1:0 and formulated with corn oil or corn starch produced 40% and 80% pigeon mortality, respectively (Table 2). Consumption of baits formulated with corn starch was 3 times greater than baits formulated with corn oil, but was still reduced 65% from pretreatment levels.

In Experiment 3, 0.25% and 0.37% DRC-1339 treated corn baits diluted 1:0 and formulated with corn starch produced 20% and 80% pigeon mortality, respectively (Table 3). Baits diluted 1:5 with untreated corn produced 10% mortality at the 0.25% concentration and no mortality at 0.37% concentration. Pigeon consumption of 0.25% and 0.37% DRC-1339 corn baits diluted 1:0 was 18% and 39% of pretreatment consumption levels. Consumption of 1:5 diluted baits by pigeons was reduced by 10% to 16% compared to pretreatment consumption levels. Pigeon regurgitation of corn kernels from undiluted (1:0) treatments was about four times greater than from 1:5 diluted treatments (Table 3).

In Experiment 4, the mortality of pigeons tested in two replications of 0.37% DRC-1339 treated corn baits formulated with corn starch was 50% and 60%. Pigeon consumption of treated corn was reduced by 73% and 79% from pretreatment consumption levels and regurgitation of corn kernels following treatment was 2.5 and 4.2 kernels/pigeon/day, respectively, somewhat less than observed in Experiment 3 (Table 3).

In summary, 0.37 DRC-1339 treated corn formulated with corn starch produced pigeon mortality of 68% in experiments (Table 4). Mortality occurred from 44 to 130 h post-ingestion with peak mortality occurring about 67 h after ingestion.

DRC-1339 Residues

In Experiment 3, to avoid suspected storage stability problems for DRC-1339 in pigeon tissue, all samples were analyzed within an hour of receipt by the analytical laboratory. Recoveries were generally consistent with those observed during validation. DRC-1339 was not detected in pigeons breast tissues but was found in two GI tract samples at about the MLOD (Table 5). Residues of this magnitude are about 80% less than the 90-day LC_{50} of 1 ppm in sensitive bird species (Schafer et al. 1977).

In Experiment 5, quantitative analysis of breast tissue show that four of nine pigeons had DRC-1339 residues between 0.06 and 0.10 μg/g, about the MLOD and the residues in the remaining five pigeons were not detectable (Table 6). The GI tract tissue samples showed that DRC-1339 residues were present at greater than the MLOD in eight of nine pigeons. However, because the analytical method was not validated for GI tract tissues containing greater than 1.8 μg/g DRC-1339, the exact concentration of three GI tracts could only be estimated. The remaining five pigeons had residues ranging from 0.13 to 0.58 ppm DRC-1339 (Table 6).

In Experiment 6, DRC-1339 residues were detectable in the breast tissue from one of two pigeons sacrificed within 3 h of force-feeding and not thereafter (Table 7). GI tract samples showed substantial decrease in DRC-1339 concentration during the 3 h period following force-feeding, however residue remained detectable for up to 24 h. At the conclusion of the test, 48 h after force-feeding, DRC-1339 concentrations were no longer detectable.

DISCUSSION

Degree of toxicity of DRC-1339 treated corn on pigeons was influenced by chemical concentration, dilution rate, consumption and adhesive agent. Daily food consumption by pigeons of DRC-1339 treated corn baits, was about 30% of normal consumption. Our findings support those of Bollengier (1968), Siebe et al. (1969), Schafer (1979) and Blanton et al. (1992) that birds, including pigeons, show a taste aversion to DRC-1339 at low concentrations and regurgitation of some baits occurs following ingestion. Thus, [illegible]ute the ineffectiveness of diluted (1:5) baits of [illegible] DRC-1339 concentration to discrimination by pigeons between untreated and treated baits. In most cases, consumption of diluted treatments did not differ from controls.

It is calculated that for 0.25% or 0.37% DRC-1339 treated corn to be 100% effective, each pigeon needs to consume 10.5 g and 7.5 g of bait, respectively, based on a DRC-1339 pigeon LD_{50} of 10-18 mg/kg (Schafer 1979) or 18 mg/kg (DeCino et al. 1966) and a 29% chemical loss in bait preparation. In our laboratory experiments, daily pigeon consumption of untreated whole corn was similar to wild pigeons collected after feeding on a whole corn bait site (Dolbeer et al. 1991). However, it was about 30% less than captive pigeons held and exposed to outside environmental factors. Pigeon food consumption will vary depending on environmental conditions. It is unknown whether the aversion effects of DRC-1339 found

Table 1. Consumption, regurgitation and mortality of pigeons free-fed DRC-1339 treated corn baits formulated with Alcolec-S in Experiment 1. January 30, 1993. Denver, Colorado.

Treatment	Pigeons (no.)	Consumption[a] Pre Ave. (g)	Consumption[a] Trt Day (g)	Regurgitation[b] Pre Ave. (no.)	Regurgitation[b] Post Ave. (no.)	Mortality[c] (%)	Mortality[c] Time (h)
Control	20	12.1	14.0	0.1	0.3	0	
0.25% 1:0	20	13.5	1.6	0.1	2.6	20[d]	72-144
0.25% 1:5	20	16.4	12.5	0	0.2	0	
0.37% 1:0	20	12.3	1.4	0	2.0	5[d]	96
0.37% 1:5	20	14.6	10.2	0	0.3	0	

[a]Consumption per pigeon per day for the pretreatment (pre) average (3 days prior to treatment) and the treatment (trt) day.
[b]Corn kernels regurgitated per pigeon per day for the pretreatment (pre) and the posttreatment (post).
[c]Time of mortality was elapsed time from treatment.
[d]Necropsies indicated that these pigeons showed signs of uremic poisoning.

Table 2. Consumption, regurgitation and mortality of pigeons free-fed undiluted 0.37% DRC-1339 treated corn bait formulated with corn starch or corn oil in Experiment 2. February 5, 1993. Denver, Colorado.

Treatment	Pigeons (no.)	Consumption[a] Pre Ave. (g)	Consumption[a] Trt Day (g)	Regurgitation[b] Pre Ave. (no.)	Regurgitation[b] Post Ave. (no.)	Mortality[c] (%)	Mortality[c] Time (h)
Starch	10	17.2	6.0	0.1	5.2	80[d]	48-120
Oil	10	15.8	2.0	0.1	2.1	40[d]	72-129

[a]Consumption per pigeon per day for the pretreatment (pre) average (3 days prior to treatment) and the treatment (trt) day.
[b]Corn kernels regurgitated per pigeon per day for the pretreatment (pre) and the posttreatment (post).
[c]Time of mortality was elapsed time from treatment.
[d]Necropsies indicated that these pigeons showed signs of uremic poisoning.

in the laboratory would be observed in the field to the same degree. If they were and the assumption was made that consumption of DRC-1339 treated bait would increase at the same ratio found in the laboratory experiments, then daily food consumption by pigeons would have to be 2.4 g for 0.37% baits and 3.4 g for 0.25% baits to be effective.

Alcolec-s® (lecithin) was initially used in Experiment 1 as an adhesive agent because laboratory formulation data indicated that the smallest loss of DRC-1339 occurred when Alcolec-s® was used in the DRC-1339 formulation. However, consumption of DRC-1339 corn baits prepared with Alcolec-s® or corn oil was less than baits prepared with corn starch. There are possible mechanisms to account for this difference. Alcolec-s®, a by-product of soybean oil production, may be detected by pigeons and found objectionable. This possibility is supported by reports that aldehydes resulting from oxidation of fatty acids (soybean or corn oils) may produce unpleasant tastes in food (Apt 1977) or enhance the taste of DRC-1339. Corn starch may serve to mask the aversive effects of DRC-1339.

DRC-1339 residue levels observed in pigeons free-feeding on 0.37% DRC-1339 treated corn diluted 1:0 were extremely low ($\leq$0.17 ppm) and only occurred in the GI tract of two birds. No DRC-1339 residues were found in breast tissue. Most scavenger and predatory species are acutely sensitive to intoxication by DRC-1339 residues only when the amount of DRC-1339 ingested exceeds 100 mg/kg. Scavengers or predators would have to consume their body weight of pigeons containing 100 ppm DRC-1339 at a single feeding to show signs of intoxication. From the data reported, the probability of this occurring is negligible. In the species (owls, ravens, crows, cats) that are sensitive to DRC-1339 poisoning, continuous and exclusive exposure to dietary levels of 1.0 ppm for 90 consecutive days would result in approximately 50% mortality of treated animals (Schafer 1984). The residue levels shown in this study for pigeons self administered or force-fed with DRC-1339 baits indicate that the potential hazard of DRC-1339 killed pigeons to any sensitive species is extremely low. Breast muscle concentrations of DRC-1339 were always at the level of detection (0.06 to 0.10 ppm). GI tract levels were also minimally present at death.

DRC-1339 treated corn baits at 0.37% concentration diluted 1:0 and formulated with corn starch were considerably more effective in producing mortality in pigeons in the laboratory than the 0.25% baits. Because of their effectiveness, the observed avoidance indicated by DRC-1339 treated corn, and regurgitation of treated baits, the 0.37% treated bait is recommended for field testing.

Table 3. Consumption, regurgitation and mortality of pigeons free-fed DRC-1339 treated corn baits formulated with corn starch in Experiments 3 and 4. March 2 and 19, 1993. Denver, Colorado.

	Pigeons	Consumption[a]		Regurgitation[b]		Mortality[c]	
Treatment	(no.)	Pre Ave. (g)	Trt Day (g)	Pre Ave. (no.)	Post Ave. (no.)	(%)	Time (h)
Experiment 3							
Control	10	15.3	16.4	0.1	0.1	0	
0.25% 1:0	10	15.6	2.8	0	6.1	20[d]	46-81
0.25% 1:5	10	17.3	15.5	0	1.5	10[d]	72
0.37% 1:0	10	17.3	6.8	0	5.9	80[d,e]	46-127
0.37% 1:5	10	18.8	15.7	0.1	1.3	0	
Experiment 4							
Control	10	17.0	16.8	0	0.1	0	
0.37% 1:0	10	17.6	3.7	0.1	2.5	50[d]	48-120
Control	10	16.2	18.0	0	0.1	0	
0.37% 1:0	10	18.1	4.8	0.1	4.2	60[d]	33-153

[a]Consumption per pigeon per day for the pretreatment (pre) average (3 days prior to treatment) and the treatment (trt) day.

[b]Corn kernels regurgitated per pigeon per day for the pretreatment (pre) and the posttreatment (post).

[c]Time of mortality was elapsed time from treatment.

[d]Necropsies indicated that these pigeons showed signs of uremic poisoning.

[e]Analyses were conducted on these pigeons to determine DRC-1339 residues in breast tissues and gastrointestinal tracts.

Table 4. Average consumption, regurgitation and mortality of pigeons free-fed DRC-1339 treated corn baits forumlated with corn starch in Experiments 2, 3 and 4. February 2, March 2 and 19, 1993. Denver, Colorado.

Treatment	Pigeons (no.)	Consumption[a] Pre Ave. (g)	Consumption[a] Trt Day (g)	Regurgitation[b] Pre Ave. (no.)	Regurgitation[b] Post Ave. (no.)	Mortality[c] (%)	Mortality[c] Time (h)
Experiment 2							
0.37% 1:0	10	17.2	6.0	0.1	5.2	80[d]	48-120
Experiment 3							
Control	10	15.3	16.4	0.1	0.1	0	
0.37% 1:0	10	17.3	6.8	0	5.9	80[d,e]	46-127
Experiment 4							
Control	10	17.0	16.8	0	0.1	0	
0.37% 1:0	10	17.6	3.7	0.1	2.5	50[d]	48-120
Control	10	16.2	18.0	0	0.1	0	
0.37% 1:0	10	18.1	4.8	0.1	4.2	60[d]	33-153
Average Control	10	16.2	17.1	0	0.1	0	
Average Treated	10	17.6	5.3	0.1	4.4	68	44-130

[a]Consumption per pigeon per day for the pretreatment (pre) average (3 days prior to treatment) and the treatment (trt) day.
[b]Corn kernels regurgitated per pigeon per day for the pretreatment (pre) and the posttreatment (post).
[c]Time of mortality was elapsed time from treatment.
[d]Necropsies indicated that these pigeons showed signs of uremic poisoning.
[e]Analyses were conducted on these pigeons to determine DRC-1339 residues in breast tissues and gastrointestinal tracts.

Table 5. Analysis of pigeon breast muscle and gastrointestinal (GI) tracts for DRC-1339 residues from Experiment 3 (free-fed 0.37 % concentration undiluted formulated with corn starch). Value shown is the average of duplicate subsamples. The Method Limit of Detection (MLOD) estimate is indicated by a "<." Denver, Colorado.

	Bird ID	Time to Death (h)	Observed Concentration (μ/g)
Breast Muscle	835-15261	46-47	<0.05 <0.05
	835-15220	46-47	<0.11 <0.11
	835-15297	46-47	<0.08 <0.08
	Control[a]	73	<0.08 <0.08
	Control[a]	73	<0.08 <0.08
	835-15223	74	<0.05 <0.05
	835-15249	125-127	<0.08 <0.08
GI Tracts	835-15261	46-47	0.19 0.15
	835-15220	46-47	0.06 0.11
	835-15297	46-47	<0.09 <0.09
	Control[a]	73	<0.14 <0.14
	Control[a]	73	<0.15 <0.15
	835-15223	74	<0.07 <0.07
	835-15249	125-127	<0.24 <0.24

[a]Pigeons were sacrificed.

Table 6. Analysis of pigeon breast muscle and gastrointestinal (GI) tracts for DRC-1339 residues from Experiment 5 where pigeons were given 58 mg DRC-1339 by gavage. Value shown is from the number of subsamples presented. The Method Limit of Detection (MLOD) estimate is indicated by a "<" and is the average of duplicate subsamples. March 8, 1993. Denver, Colorado.

	Bird ID	Time to Death (h)	Observed Concentration (μ/g)
Breast Muscle	835-15256	29	<0.13
			<0.13
	835-15247	31-43	<0.67
			<0.67
	835-15257	45	<0.086
			<0.086
	835-15245	31-43	<0.085
			0.10
	835-15241	31-43	<0.061
			0.098
	835-15219	31-43	0.079
			0.067
	835-15285	31-43	<0.087
			<0.087
	835-15303	31-43	<0.079
			<0.079
	835-15282	48	0.061
			<0.082
GI Tracts	835-15256	29	>11
			>4.7
	835-15247	31-43	0.23
			0.17
			0.23
	835-15257	45	0.42
			0.33
			0.36
	835-15245	31-43	>17
			>14
	835-15241	31-43	0.25
			0.28
			0.19
	835-15219	31-43	0.39
			0.34
	835-15285	31-43	0.13
			0.58
	835-15303	31-43	>3.2
			>2.3
	835-15282	48	<0.10
			<0.10

Table 7. Analysis of pigeon breast muscle and gastrointestinal (GI) tracts for DRC-1339 residues from Experiment 6 where pigeons were force-fed 21 whole corn kernels treated with 0.37% DRC-1339. Value shown is from the number of subsamples presented. The Method Limit of Detection (MLOD) estimate is indicated by a "<" and was from a single fortified subsample. March 30, 1993. Denver, Colorado.

	Bird ID	Sample Time (h)	Observed Concentration (μ/g)
Breast Muscle	134	0	1.2 0.99
	244	0	1.1 1.1
	144	3	0.16 0.16 0.11 0.15
	193	3	<0.13
	160	6	<0.14
	139	6	<0.13
	172	12	<0.11
	114	12	<0.11
	171	24	<0.10
	106	24	<0.12
	100	48	<0.10
	133	48	<0.13
GI Tracts	134	0	>59 >44
	244	0	>35 >15
	144	3	5.6 5.5
	193	3	1.0 1.1
	160	6	8.2 7.8
	139	6	2.6 2.6
	172	12	0.43 0.51
	114	12	0.14 0.10
	171	24	0.23 0.40
	106	24	<MLOD[a]
	100	48	<0.14
	133	48	<0.18

[a]No spike was made to determine MLOD for this pigeon.

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LITERATURE CITED

APT, C. M. 1977. Flavor: Its chemical, behavioral, and commercial aspects. Proc. Arthur D. Little, Inc. Flavor Symposium. 229 pp.

BENENSON, A. S., editor. 1985. Control of communicable diseases in man. Fourteenth ed. The American Public Health Association, Washington, D.C. 485 pp.

BLANTON, K. M., B. U. CONSTANTINE, and G. L. WILLIAMS. 1992. Efficacy and methodology of urban pigeon control with DRC-1339. Proc. East. Wildl. Damage Control Conf. 5:58-62.

BOLLENGIER, R. M., Jr. 1968. Vagrant pigeon control using DRC-1339 - Test site: Concord, New Hampshire. Den. Wildl. Res. Ctr., Technical Rep. 14 pp.

DECINO, T. J., D. J. CUNNINGHAM, and E. W. SCHAFER, Jr. 1966. Toxicity of DRC-1339 to Starlings. J. Wildl. Manage. 30:249-253.

DOLBEER, R. A., P. P. WORONECKI, and S. D. FAIRAIZL. 1991. Field test of alpha chloralose to capture nuisance pigeons. Den. Wildl. Res. Ctr., Bird Damage Res. Rep. No. 470. 11 pp.

FAGERSTONE, K. A., and E. W. SCHAFER, Jr. 1988. Bird control registration needs. Den. Wildl. Res. Ctr., Bird Damage Res. Rep. No. 407. 10 pp.

KREPS, L. B. 1974. Feral pigeon control. Proc. Vertebr. Pest Conf. 6:257-262.

KRZYSIK, A. J. 1987. A review of bird pests and their management. Dept. Army, U.S. Corps of Engineers, Technical Rep. REMR-EM-1. 114 pp. with appendices.

PACKHAM, C. J., and G. CONNOLLY. 1992. Control methods research priorities for animal damage control. Proc. Vertebr. Pest Conf. 15:12-16.

SCHAFER, E. W., Jr. 1979. Physical, chemical and biological properties of CPT, CPTH, CAT, CPT-C, and CPT-D. Den. Wildl. Res. Ctr., Bird Damage Res. Rep. No. 121. 81 pp.

SCHAFER, E. W., Jr. 1984. Potential primary and secondary hazards of avicides. Proc. Vertebr. Pest Conf. 11:217-222.

SCHAFER, E. W., Jr., R. B. BRUNTON, D. J. CUNNINGHAM, and N. F. LOCKYER. 1977. The chronic toxicity of 3-chloro-4-methyl benzenamine HCl to birds. Arch. Environ. Contam. Toxicol. 6:241-248.

SCOTT, J. G. 1961. Pigeons-public health, importance and control. Pest Control 9:9-20, 60-61.

SIEBE, C. C., P. E. LEVINGSTON, J. D. SMITH, and D. ADAMS. 1969. Use of Starlicide for pigeon control: trial. California Dept. of Agr. Tech. Rep. 3 pp.

THEARLE, R. J. P. 1968. Urban bird problems. pp. 181-197 *in* R. K. Murton and E. N. Wright, eds. The Problems of Birds as Pests. Academic Press, New York, N. Y. 254 pp.